Space Weather Technical Forecast

Issued on Saturday, 30 October 2021 at 01:24 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: CME arrival expected day 1 (30th) with G1/G2 Minor to Moderate storms and isolated G3 Strong Storms day 1 and day 2. G3 Watch issued. Low to Moderate solar Activity. S1 Proton Storm ongoing.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity was Moderate with one M1-class flare at 29/0244UTC from AR2891 Dkc/Beta-Gamma in the northeast disc. AR2887 Csi/Beta-gamma, which was the source of an X1-flare and associated CME on 28th has simplified a little in the last 24 hours, with two further small and simple sunspots on the disc AR2886 Hsx/alpha approaching the southwest limb and a new unnumbered region in the centre north disc. No further Earth-directed CMEs were observed in available imagery in the last 24 hours.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured by DSCOVR at L1 was at background level near 300km/s but rose slightly to 310-320km/s from 29/2000 UTC. The density was initially at average levels, but rose to be above average, peaking at just over 20 ppcc at 29/1740 UTC, before declining again to average levels. The strength of the interplanetary magnetic field (IMF), Bt, was weak throughout and below 6nT, with the north-south Bz component between +5 and -5 nT. The phi angle was mainly in the negative sector (Towards the Sun), but gradually rotated to be briefly positive by 29/1600 UTC. Geomagnetic activity remained Quiet throughout, Kp 0-2.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured by GOES-16 has been at S1 minor storm throughout, peaking at 29 pfu at 29/0700 UTC, before gradually declining. The 100 MeV Protons have also been at active thresholds (above 1pfu) throughout, but have fallen from 4 pfu to near 1 pfu by 29/0000Z. The high energy electron flux (greater than 2 MeV) was predominantly at background levels with the associated 24-hour electron fluence below the Active (1e8 integrated pfu) threshold, with 1.77e6 integrated pfu recorded at 30/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar Activity is forecast is forecast to be Moderate to Low over the next 4 days with a chance of further M-class flares and slight chance (10%) of another X-class flare, primarily from AR2891.

Solar Wind / Geomagnetic Activity: A large CME from an X-class flare eruption on the 28th has been analysed and is forecast to arrive at Earth during the second half of Day 1 (30th), most likely around 1600UTC. Geomagnetic activity is expected to be quiet until then (Kp0-2). During the CME transit, minor to moderate geomagnetic storms (G1/G2 Kp5-6) are expected, with a likelihood of isolated G3/Strong storms (Kp7). Geomagnetic activity is then expected to gradually subside during the latter part of Day 2 into Day 3 (31st and 1st) with an eventual return to Quiet to Unsettled, with a chance of Active intervals (Kp2-4). A further solar wind enhancement is possible late on day 4 (2nd) due to the arrival of the fast wind of CH16, with Active to G1/Minor Storm intervals possible.

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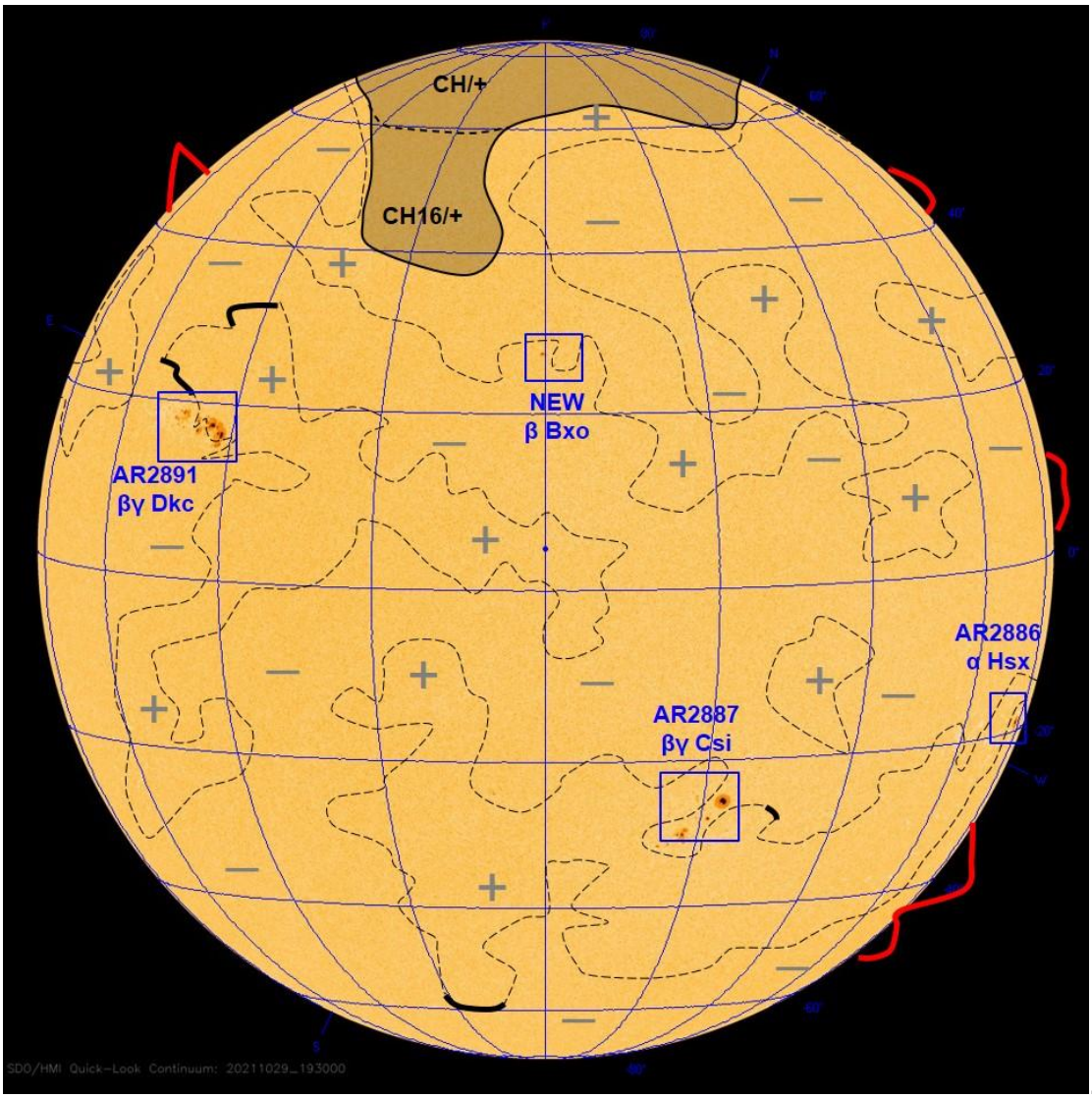
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to be above S1 level at first, declining through day 1 (30th) and likely falling below the S1 level day 2 (31st). There is an ongoing 5% chance of further enhancement from any notable flares. The high energy electron flux (greater than 2 MeV) is forecast to remain mostly at background levels between days 1 and 2 (30th and 31st), but with a risk of exceeding the Active level (1e3pfu) threshold at times later day 2 and day 3 (31st into the 1st) as geomagnetic activity following the expected CME arrival subsides. From a low start, the associated 24 hour fluence is expected to remain largely below the Active (1e8 integrated pfu) level, but with a slight chance of exceeding this threshold on day 3 or 4 (1st November).

Figure 1. Solar Analysis Valid *.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A large full-halo CME was observed leaving the sun in coronagraph imagery following the X-class flare from AR2887 on the 28th at 1535UTC. This feature has been analysed, is Earth-directed, and currently expected to arrive 30/1200-2400 UTC, with most likely arrival time of 1600 UTC. A further small eruption that occurred on the 26/2000 UTC has the potential to give glancing effects on passing behind the Earth on day 1 (30th) or early day 2 (31st), but anything from this is likely to be swept up in the larger CME.

Solar winds are currently at background levels, and expected to become enhanced with the CME arrival, before easing day 3 (1st) onward. Later day 4 (2nd), a further enhancement is possible from the arrival of the fast wind of positive polarity coronal hole 16, which is a southern extension of the northern polar crown.

Geomagnetic activity is forecast to be mainly Quiet at first day 1 (30th), Minor to Moderate Geomagnetic storms (G1/G2) are then expected with the CME, with a likelihood of isolated G3/Strong storms (Kp7). Geomagnetic activity is then expected to gradually subside later day 2 and more especially day 3 (31st to 1st November) with an eventual return to Quiet to Unsettled levels, with a chance of Active intervals (Kp2-4). There is then a chance of G1/Minor storm intervals later day 4 from any fast wind arrival from CH16.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	90	80	40	30
Strong	G3	No	60	60	5	1
Severe	G4	No	10	10	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Name	Liftoff Time	Long	Lat	Radial Speed (km/s)	Half Angle	Time at 21.5Rs	Comment
CME-202110-041	28/10/2021 15:35	1E	20S	1200	52	28/10/2021 18:44	Large Earth-directed Full Halo CME from X1 flare (AR2887)

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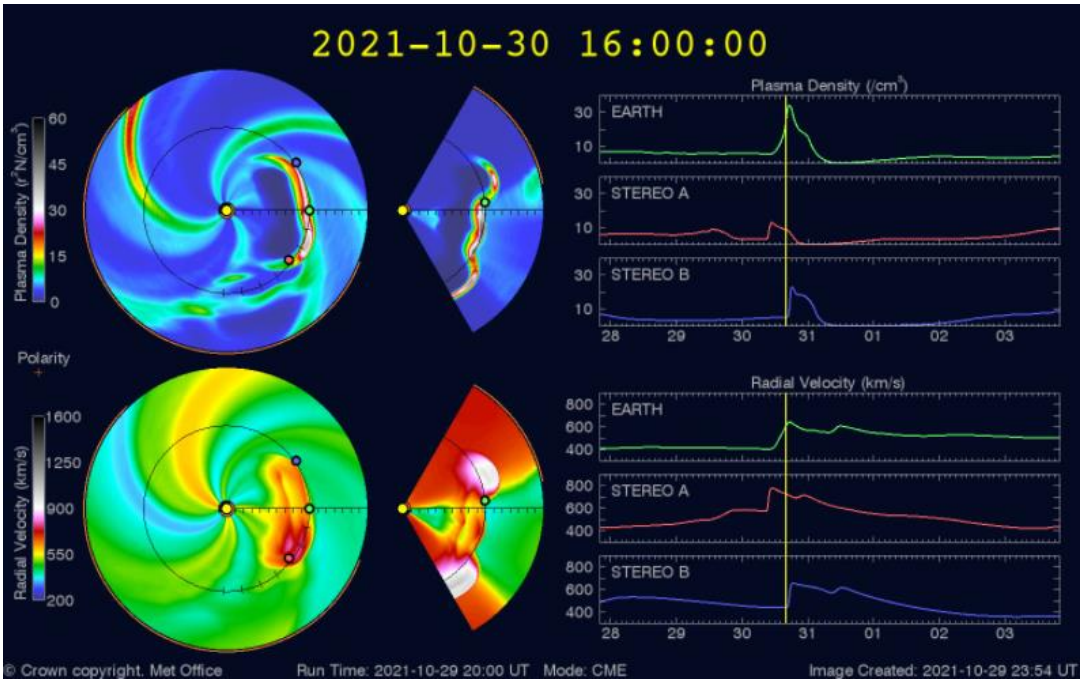
Figure 2: Enlil showing expected CME arrival with ensemble below



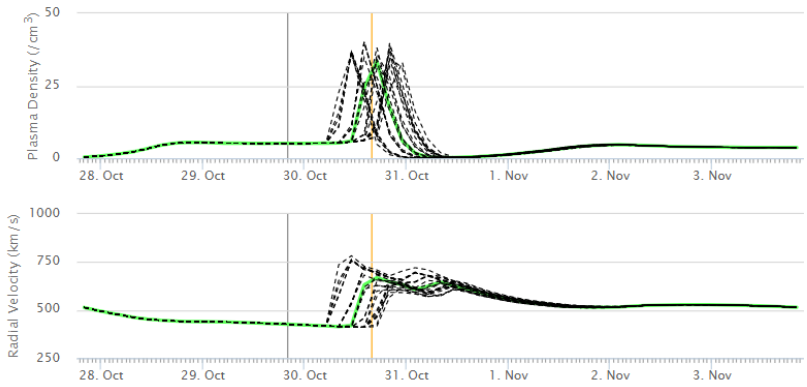
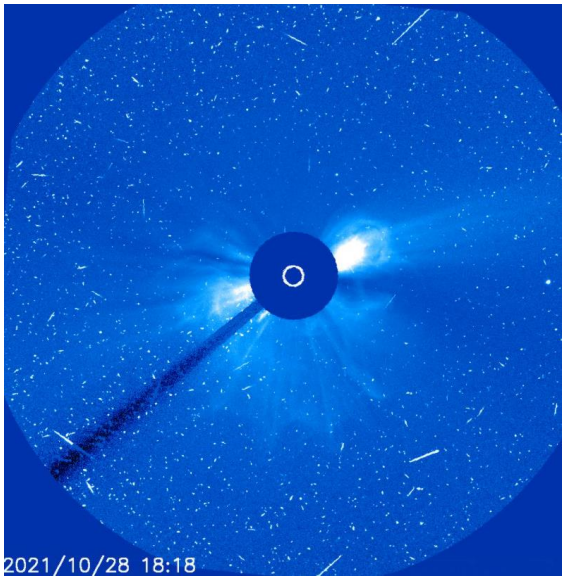


Figure 3: SOHO LASCO C3 of CME on 28th.



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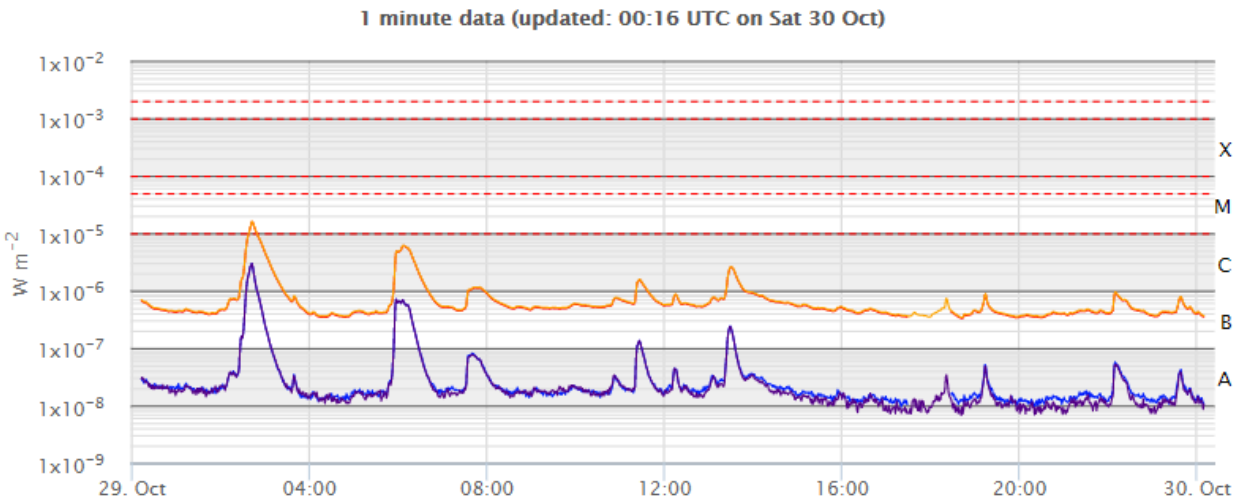
Radio Blackouts - X-Ray Flares:

Solar Activity is currently Moderate with four sunspots on the Earth-facing disc, and one M-class flare in the last 24 hours, from AR2891 Dkc/Beta-gamma in the northeast. This region is currently the most complex of the four, and has been showing signs of slow development, including a reverse polarity region developing to the south of the main leader. AR2887 Csi/Beta-gamma is now west of the southern centre disc, but has simplified somewhat since the X1-flare on the 28th, and is now a chain of larger negative spots with much smaller positive polarity spots on either side. The other two regions are both small and simple, with AR2886 Hsx/alpha approaching the southwest limb as a mature and stable spot, with a new sunspot Bxo/Beta having also developed in the north centre disc. The other sunspot regions have dissipated, although some looping around the northeast limb of SDO aia-171 signals the potential for a further sunspot region to rotate on the visible disc during day 1 (30th).

Solar Activity is forecast to be Moderate to Low, with the main activity from AR2891, but with the potential for further flares from AR2887, although this risk decreasing. There is a slight chance of further low X-flares (R3 Radio Blackouts)

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	40	40	40	40
Very Active	R3 to R5 X Class	No	10	5	5	5

Figure 4: GOES-16/17 X-ray flux



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently at S1/Minor storm levels. In the absence of any further significant flares the high energy proton flux is expected to gradually decline, but likely remaining above the S1 level until day 2 (31st), but with a chance of falling below day 1 (30th). There is a 5% chance of a further enhancement from any notable flares that occur, with AR2887, which was the source of the X-flare and subsequent protons storm, having now simplified a little.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	60	10	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: GOES-16 Proton Flux (10 MeV Blue, and 100 MeV Green)

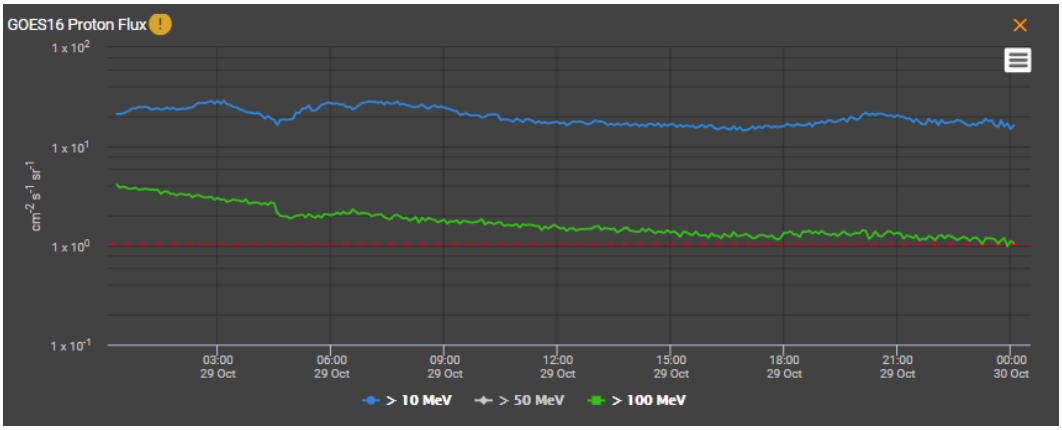
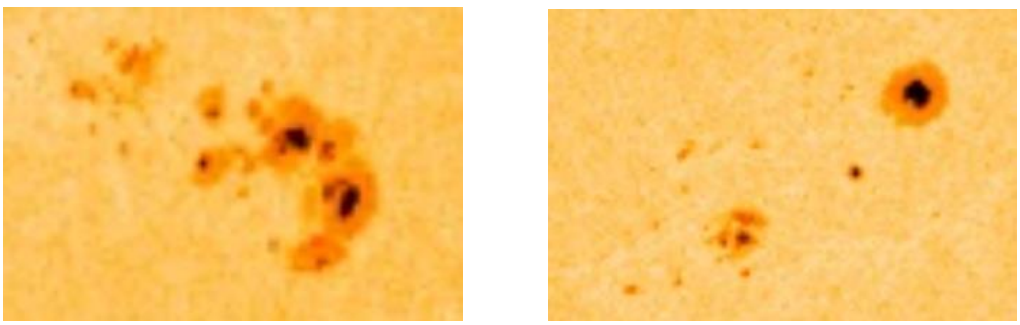


Figure 6: Intensitygram of AR2891 (left) and AR2887 (right)



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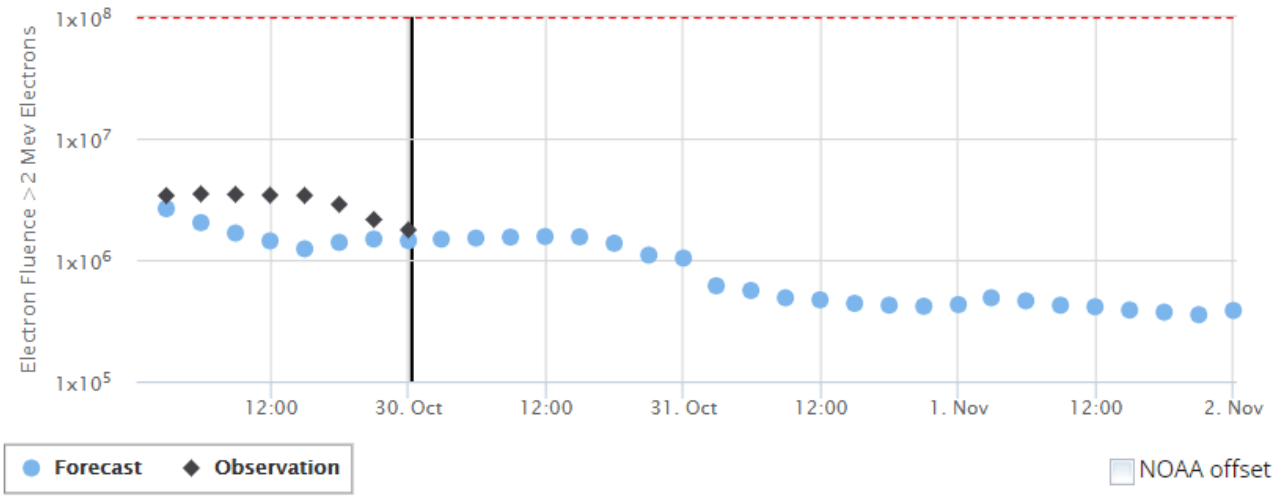
High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2 MeV) as observed by GOES-16 at GEO is currently at background levels and expected to persist at this or moderate levels for much of the period. The expected arrival of the CME on day 1 (30th) has the potential to inject electrons into the Van Allen radiation belts. As geomagnetic activity resides a little day 2 (31st) onward, this would then likely be observed at GEO, with electron flux potentially increasing to above the alert threshold (1000 pfu) although confidence is low. This giving a chance of reaching the Active fluence threshold (1e8 integrated pfu) day 3 onward (1st). REFM is expected to give reasonably good guidance at first, but doesn't take account of the expected CME arrival on the 30th.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	20	30	30
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 7: GOES-16 Electron Fluence with REFM



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